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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) **International Patent Classification** 6 : **H04B 7/005, 17/00**

A1

(11) **International Publication Number:** **WO 99/43101**

(43) **International Publication Date:** 26 August 1999 (26.08.99)

(21) **International Application Number:** PCT/US99/03683

(22) **International Filing Date:** 19 February 1999 (19.02.99)

(30) **Priority Data:**
60/075,211 19 February 1998 (19.02.98) US

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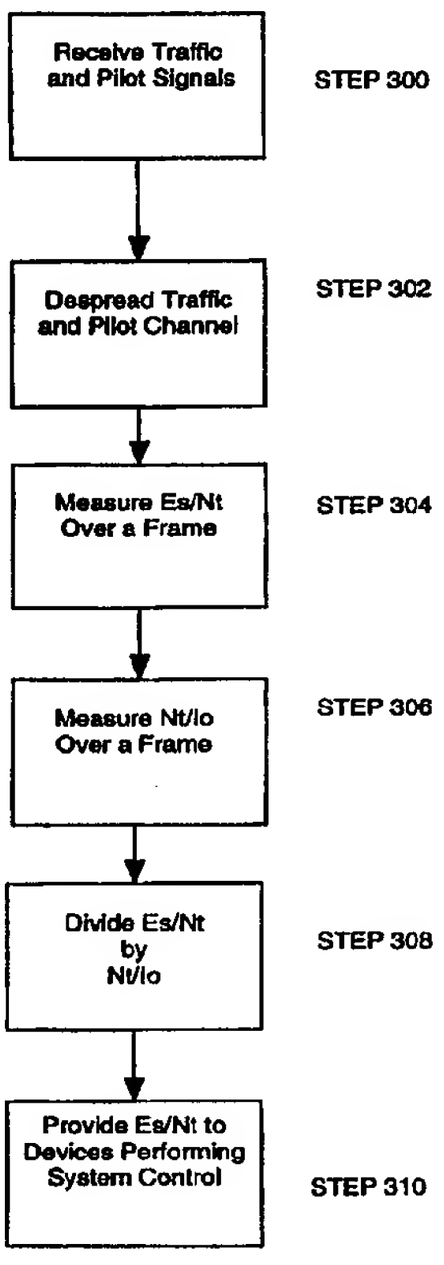
(81) **Designated States:** AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) **Title:** FORWARD LINK POWER CONTROL IN A CELLULAR SYSTEM USING N_T/I_0 VALUES

(57) **Abstract**

A system and method is taught for controlling the power level of transmissions within a communication system having a base station, a mobile station, a communication channel, and a pilot channel. The mobile station determines a signal strength value according to a communication signal received by way of the communication channel. A pilot channel signal is determined according to a pilot signal transmitted by way of the pilot channel. The signal to noise ratio of the communication signal is determined according to the determined signal strength value and the pilot channel signal. The power level of a transmission is controlled according to the signal to noise ratio. The noise level in a communication channel within the communication system is estimated. The pilot channel signal includes pilot energy and pilot noise components. The pilot energy component is removed to provide a remaining pilot signal. Communication system operations are controlled according to the remaining pilot signal. The power levels of transmissions are controlled by determining the signal to noise ratio of a signal within the communication channel and determining a difference signal. The difference signal is formed by determining the difference between determined and desired signal to noise ratios. The difference signal is transmitted between the base station and the mobile station. The pilot channel has at least one frame and the power control signal is inserted into the frame. Thus, information representing the strength of the communication signal is transmitted to the base by way of the pilot channel within the frame. The pilot channel can have two information frames for transmitting the power control signal a plurality of times.



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FORWARD LINK POWER CONTROL IN A CELLULAR SYSTEM USING N_T/I_0 VALUES

BACKGROUND OF THE INVENTION

I. Field of the Invention

The present invention relates to communications systems in general, and to power control in a communications system in particular.

II. Description of the Related Art

There are many in prior art communications systems that require a measurement of the strength of a signal received by a mobile station. For example, during handoff of a mobile station from one base station to another a determination of the strength of the signals received by the mobile station is desirable for determining when to perform the handoff. One such handoff technique is disclosed in U.S. Patent No. 5,267,261, entitled "MOBILE STATION ASSISTED SOFT HANDOFF IN A CDMA CELLULAR COMMUNICATIONS SYSTEM," assigned to the assignee of the present invention.

In the improved technique of U.S. Patent No. 5,267,261 the mobile station monitors the signal strength of pilot signals transmitted by neighboring base stations within the system. The mobile station sends a signal strength message to a system controller via the base station through which the mobile station is communicating. Command messages from the system controller to a new base station and to the mobile station in response to the signal strength are thus used to establish communication through the new and current base stations. The mobile station detects when the signal strength of a pilot corresponding to at least one of the base stations through which the mobile unit is currently communicating has fallen below a predetermined level. The mobile station reports the measured signal strength indicative of the corresponding base station to the system controller via the base stations through which it is communicating. Command messages from the system controller to the identified base station and mobile station terminate communication through the corresponding base station while communications through the other base station or stations continue.

It is known for the power control information transmitted from the mobile station to be inserted into a dedicated control channel separate from the traffic channel. However it is desirable to decrease the need for separate control channels. Additionally, while it is preferably for the power of the energy of the signal sent on the traffic channel to be used to determine the power control parameters, it is known for the control information to be based upon the error rate rather than the signal to noise ratio because the signal to noise ratio of the traffic channel is difficult to measure. For example, in some current systems, the time between errors is used to indicate the error rate. The error rate is then used to determine the quality of the traffic channel. Furthermore, it is difficult to obtain power control information and utilize it in time to respond to the conditions indicated in the power control information.

SUMMARY OF THE INVENTION

A system and method is taught for estimating the relative amount of power that is provided on the traffic channel using a calculated amount of noise that is present on a pilot channel. This estimate may then be used for several purposes, including controlling the power level of transmissions within a communication system having a base station, a mobile station and a plurality of channels including a communication channel and a pilot channel. The mobile station measures the ratio of the amount of energy received per symbol to the amount of interference received. The amount of energy received over the pilot channel is used to determine the amount of noise received in the pilot channel. The signal to noise ratio of the communication signal is determined according to the determined signal strength value and the pilot channel noise value. Accordingly, in one embodiment of the disclosed method and apparatus, the power level of a transmission is controlled according to the calculated signal to noise ratio.

A system and method is also taught for estimating the noise level in a communication channel within the communication system. The pilot signal includes a pilot energy component and a pilot noise component. The pilot energy component is removed from the pilot channel signal to provide a

remaining pilot signal. As noted above, the amount of noise in the channel is estimated based upon the amount of noise in the pilot channel.

As noted above, in accordance with systems, the power of transmitted signals is controlled based upon an indication of the amount of power received by the intended receiving device. In such systems, the power levels of transmissions are controlled by determining difference between the signal to noise ratio of a received signal and the desired signal to noise ratio. A transmitter transmits the difference signal between the base station and the mobile station.

The pilot channel is divided in time into frames and the power control signal is inserted into each frame. Thus, information representative of the strength of the communication signal is transmitted to the base station by way of the pilot channel within each frame.

BRIEF DESCRIPTION OF THE DRAWINGS

The features, objects, and advantages of the present invention will become more apparent from the detailed description set forth below in conjunction with the drawings in which like reference characters identify correspondingly throughout and wherein:

FIG. 1 shows an exemplary illustration of a cellular communication system;

FIG. 2 shows a power control subchannel within the cellular communication system of Fig. 1;

FIG. 3 is a flow chart illustrating the steps performed to determine signal to noise ratio of a received traffic signal;

FIG. 4 is a detailed flow chart illustrating certain steps of FIG 3; and

FIG. 5 is a block diagram of the disclosed apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

An exemplary illustration of a cellular communication system is provided in FIG. 1. The system illustrated in FIG. 1 can use various multiple access modulation techniques for facilitating communications between a large number of system mobile stations (or mobile communication devices), and the base stations. These techniques include CDMA spread spectrum modulation.

In a typical CDMA system, the base stations transmit a unique pilot signal including a pilot carrier upon a corresponding pilot channel. For example, in accordance with one embodiment of the disclosed method and apparatus, the pilot signal is an unmodulated, direct sequence, spread spectrum signal transmitted at all times by each base station using a common pseudorandom noise (PN) spreading code. The pilot signal allows the mobile stations to obtain initial system synchronization, in addition to providing a phase reference for coherent demodulation and a reference for signal strength measurements. Furthermore, the received pilot signal can be used to estimate the arrival time, phase and amplitude of the received traffic signal. In accordance with one embodiment of the disclosed method and apparatus, the pilot signal transmitted by each base station is modulated with the same PN spreading code with different code phase offsets.

A system controller 10, also referred to as a mobile switching center (MSC) 10, typically includes interface and processing circuitry for providing system control to the base stations. The controller 10 also controls the routing of communication device calls from the networks (such as the public switched telephone network (PSTN)) to the appropriate base station for transmission to the appropriate mobile station. The routing of calls from mobile stations through base stations to the PSTN is also controlled by the controller 10.

The controller 10 can be coupled to the base stations 12, 14, 16 by various means such as dedicated phone lines, optical fiber links or by microwave communication links. In FIG. 1, three base stations 12, 14, 16 and a communication device (such as a mobile station) 18 are illustrated. The mobile station 18 consists of at least a receiver, a transmitter, and a processor. The base stations 12, 14, 16 typically include processing circuitry for controlling the

functions of the base stations 12, 14, 16, and interface circuitry for communicating with both the mobile station 18 and the system controller 10.

The Arrows 20A-20B shown in FIG. 1 represent the possible communication link between the base station 12 and the mobile station 18. The Arrows 22A-22B shown in FIG. 1 represent the possible communication link between the base station 14 and the mobile station 18. Similarly, the arrows 24A-24B shown in FIG. 1 represent the possible communication link between the base station 16 and the mobile station 18.

After a mobile station 18 processes a received signal, the resulting signal is a composite of a desired signal and a noise signal. The signal to noise ratio averaged over some period of time is a good measure of the strength of the received signal. For example, in a CDMA system the signal to noise ratio of the received signal can be averaged over a block. The mobile station 18 can, therefore, estimate the signal to noise ratio and compare the estimate with the value the mobile station 18 actually received. In accordance with one embodiment of the disclosed method and apparatus, the mobile station 18 sends to the base stations 12, 14, 16 the resulting difference between the measured and expected values of the signal to noise ratio as a parameter (FWD_SNR_DELTA) represented in units of decibels. The parameter (FWD_SNR_DELTA) is preferably transmitted on a reverse link power control subchannel.

In determining the expected signal to noise ratio, the mobile station 18 calculates a signal to noise ratio that will result in an average forward link fundamental block erasure rate equal to the forward link fundamental block erasure rate configured by the base stations 12, 14, 16. In calculating the expected signal to noise ratio, the mobile station 18 assumes that successively lower rate blocks are transmitted with three decibels less power per PN chip. In accordance with one embodiment of the disclosed apparatus, the mobile station 18 performs maximal ratio combining of the receive paths.

In addition to calculating the expected signal to noise ratio, the mobile station 18 must determine the signal to noise ratio of the received traffic signal. The flowchart of Figure 3 is a high level flowchart that illustrates the steps that are performed in order to determine the signal to noise ratio of the received

traffic signal. Initially, the traffic and pilot signals are received (together with any noise on the channel) (STEP 300). While filters remove noise that is out of the frequency band over which the traffic and pilot signals are transmitted, noise that is in-band, is passed. The received traffic signal is decover by the particular Walsh code used to channelize the traffic channel. Likewise, the pilot channel is decover by the particular Walsh code used to channelize the pilot channel (STEP 302). Once the pilot and traffic channels have been decover, the per symbol signal to interference E_S/I_o is measured (STEP 304). Next, the noise to interference, N_t/I_o is measured (STEP 306). Once these values are measured, the per symbol signal to interference, E_S/I_o is divided by the N_t/I_o to yield the per symbol to noise ratio, E_S/N_t (STEP 308). This value is then provided to devices that use the per symbol to noise ratio E_S/N_t to control the system (STEP 310), such as by performing power control of the forward link transmit signal. The details as to how STEPs 304 and 306 are performed are provided in the flowchart in FIGURE 4.

It should be understood by those skilled in the art that prior to decovering to separate the orthogonal channels, each of the traffic channels is included in the noise on the pilot channel. Likewise, the pilot signal and each of the traffic channels, except the traffic channel of interest, are included in the noise of the traffic channel of interest. Once decovered, the noise in the traffic channel includes only energy associated with non-orthogonal signals. It should further be understood by those skilled in the art that an automatic gain control device is typically used to ensure that the total received signal is received at an essentially constant value. Accordingly, all of the signal values are referenced to the total received signal strength, I_o. Nonetheless, this is not noted in the equations that follow. Accordingly, the total received traffic signal can be represented as:

$$r_T = s_T + n_T \qquad \textbf{EQN. (1)}$$

where s_T represents the desired traffic signal and n_T represents the noise in the received traffic signal. It will be understood that:

$$s_T = \Sigma d_k \, E_{s,k}^{1/2} \qquad \textbf{EQN. (2)}$$

where d_k is the k^{th} symbol within the symbol stream or data stream of the traffic channel; and $E_{T,k}$ is the total received energy of the traffic channel over a symbol. The sum is taken for all k from 1 to n, where n is the total number of symbols in a frame. It should be noted that in an alternative embodiment of the disclosed method and apparatus, the number of symbols, n may differ from the number of symbols in a frame.

In many cases, a "rake" receiver is used to combine signals received from different sources or signals from the same source that have traversed different paths (and thus are delayed with respect to one another). In such cases, the total received traffic signal is attained by multiplying the traffic signals received on each independent path by the associated pilot signals. This multiplication results in each received traffic signal being weighted by the relative strength of the associated pilot signal. These products are then summed to form the total received traffic signal r_T. The following equation represents this sum:

$$r_T = \Sigma\, r_{T,i} \langle r_{p,i} \rangle \qquad \textbf{EQN. (3)}$$

where the sum is taken over the subscript i from 1 to m, $r_{T,i}$ is the received traffic signal for the i^{th} path, m is the total number of paths, and the brackets which enclose the term $r_{p,i}$ indicate the fact that the pilot signal may be filtered by a low pass filter to reduce any fluctuations in the amplitude of the pilot over short periods in time.

The total received pilot signal for a particular path can be represented as:

$$r_{P,i} = s_{P,i} + n_{P,i} \qquad \textbf{EQN. (4)}$$

where s_P represents the received pilot signal and n_P represents the pilot noise.

In addition, the pilot signal value $s_{p,i}$ is equal to the data times the square root of the energy per symbol, E_s and a scaling factor. This relationship can be represented as follows:

$$s_{P,i} = \alpha\Sigma(d_k E_{S,k}^{1/2}) \qquad \textbf{EQN. (5)}$$

where: α is a scaling factor which takes into account the relative transmission gains of the traffic and pilot channels and the integration lengths for each channel; the sum is taken over the subscript k from 1 to n; n is the total number of symbols; d_k is the k^{th} symbol of the symbol stream or data stream of the pilot channel; and $E_{S,k}$ is the total received energy of the pilot channel over the k^{th}

symbol. The symbol stream *d* is essentially either a positive one or a negative one representing the state of the information modulated on the pilot channel. In the case of the pilot signal, it is typical for the data to have a constant value of one. Therefore, the data, *d* can be dropped from the equation. In multiplying a traffic signal with a pilot signal, Eqn. (2) can be substituted into Eqn. (1), and Eqn. (5) can be substituted into Eqn. (4). The resulting produce is then:

$$r_T = [(\Sigma d_k E_{S,k}^{1/2})_i + n_{T,i}] \bullet [\alpha\Sigma(d_k E_{S,k}^{1/2})_i + n_{p,i}] = d\alpha E_S + \text{noise} \qquad \textbf{EQN. (6)}$$

However, if the noise n_P of the pilot signal r_P and the noise n_T of the traffic signal r_T are uncorrelated, then the product r_T is essentially a scaled unbiased estimator of the traffic data multiplied by the traffic signal energy. This is due to the fact that the uncorrelated noise will not sum up. However, the correlated data does sum up. Accordingly, an assumption can be made that the noise is negligible (i.e., insignificant and can be ignored). It can reasonably be assumed that the noise n_P of the pilot signal r_P and the noise n_T of the traffic signal r_T are uncorrelated, because the pilot signal r_P and the traffic signal r_T are transmitted on orthogonal channels.

Since *d* is essentially random and unknown, it is desirable to eliminate *d* from Eqn. (6). In accordance with the disclosed method and apparatus, in order to eliminate *d* from Eqn. (6), a dot product is performed. The dot product is taken between the estimator $d\alpha E_T$ and the symbol stream *d* after decoding and re-encoding of the received traffic signal (STEP 400). By decoding the traffic information, the information is essentially extracted from the received signal. Re-encoding the information returns the information to the state in which it existed before the decoding. Since the data sequence is relatively well known after the decoding operation, performing this dot product allows the data sequence to be taken into account when determining the energy of the received signal. That is, the dot product projects the data onto the received signal. Accordingly, the energy in the information symbols is summed and the energy in the noise is not, since the noise is uncorrelated. Naturally, the more symbols are summed, the greater the ratio of symbol energy to noise. The result of the dot product operation is:

$$\alpha E_T \bullet \alpha E_T = (\alpha E_T)^2 \qquad \textbf{EQN. (7)}$$

In order to estimate the traffic channel signal energy, the scaling factor α is removed from Eqn. (7). Scaling factor α can be represented as:

$$\alpha = G_P/G_T \bullet L_P/L_T \qquad \textbf{EQN. (8)}$$

where G_P is the pilot signal transmission gain, G_T is the traffic transmit signal transmission gain, L_P is the integration period of the pilot signal, and L_T is the integration period of the traffic signal. While the pilot integration period L_P and the traffic integration period L_T are known, the relationship between the pilot signal gain G_P and the traffic transmit signal gain G_T is typically not known in cases in which power control factors change the gain of the traffic channel.

Therefore, in order to eliminate the scaling factor α, the mobile station 18 determines the pilot energy by computing the dot product of the pilot signal with itself. This produces a biased estimate of the pilot energy E_P which is a scaled biased estimate of the signal energy, $E_P = \alpha^2 E_T$. Therefore, a biased estimate of the traffic signal energy E_T can be determined by squaring the unbiased estimator, αE_T of the traffic signal energy and dividing it by the biased estimator of the pilot signal energy E_P:

$$E_T = (\alpha E_T)^2 / (\alpha^2 E_T) \qquad \textbf{EQN. (9)}$$

As noted above in Eqn. (7), the energy per symbol, E_S can then be attained by normalizing the value E_T with respect to a symbol (i.e., by dividing by the number of symbols over which E_T was determined, such as the number of symbols per frame) (STEP 402). Accordingly:

$$E_T / n = E_S \qquad \textbf{EQN. (10)}$$

where n is the number of symbols over which E_T was determined.

If the fundamental block rate of the received traffic signal is known (STEP 404), then the normalized dot product associated with the block rate is selected (STEP 406). However, if the fundamental block rate is not known (STEP 404), then the dot product that has the maximum value is selected (STEP 408).

The disclosed method and apparatus takes advantage of the fact that the pilot signal has a known constant data sequence. Since the data sequence is

known, the pilot channel signal can be easily differentiated to isolate the noise content (STEP 410). In accordance with one embodiment of the disclosed method and apparatus, this is done by inverting the pilot channel, shifting the inverted pilot channel signal one symbol in time with respect to the unshifted pilot channel signal, and summing the shifted inverted pilot channel signal with the unshifted pilot channel signal. This can also be done by decovering the pilot channel with Walsh code W_{64}^{128} and integrating over the frame. This particular Walsh code is a pattern of alternating positive ones and negative ones. Thus, the sum of the energy in the pilot channel over a discrete number of symbols is zero, thereby isolating the remaining N_T term. This permits a determination of the normalized noise of the pilot channel.

The desired value, which is the signal to noise ratio is E_S/N_T, can be attained by simply dividing the value E_S by the value N_T.

Figure 5 is a simplified block diagram of the disclosed apparatus. A radio frequency (RF) receiver 501 receives the incoming signal and does RF processing in known fashion. The received signal is then coupled to a processor 503. A Walsh decovering circuit 511 within the processor 503 decovers each of the traffic channels and the pilot channel. It will be understood by those skilled in the art that the Walsh decovering circuit 511 may be implemented either as software run on the processor 511, as a circuit which is implemented using discrete components, an application specific integrated circuit (ASIC) which is distinct from the processor 511, or in any other manner that would allow the decovering procedure to be accomplished, as is well known in the art. Once decovered, the traffic channel signal is coupled to a decoder 507. Similar to the decovering circuit, the decoder 507 may be implemented using discrete components, an application specific integrated circuit (ASIC) which is distinct from the processor 511, or in any other manner that would allow the decoding procedure to be accomplished, as is well known in the art. The decoding process results in the information that was originally encoded by the transmitter that transmitted the received signal. This information is then coupled to a re-encoder 509. The re-encoder 509 may be implemented using discrete components, an application specific integrated circuit (ASIC) which is distinct from the processor 511, or in any other manner that would allow the re-

encoding procedure to be accomplished, as is well known in the art. Once the re-encoding function has been performed, the processor 503 performs the functions described above to determine the E_S/N_T value. This value is then coupled to a communication network controller 505, such as the processor within a base station that is responsible for controlling the forward link power control, or the processor within a mobile cellular telephone that is responsible for communicating the amount the forward link power control should be adjusted in order to maintain a desired transmission power. It should be noted that the particular use to be made of the E_S/N_T value is not intended to be limited by the particular embodiments that are disclosed herein, but should be understood to include all possible applications of this quality value.

The mobile station 18 can also calculate the measured normalized signal to noise ratio, E_f/N_t, on a per frame basis. The normalized per frame signal to interference ratio E_f/R is measured, where R is the total signal received and E_f is the energy of the desired signal during a single frame. The per frame noise to interference ratio, N_t/R, is then measured. E_f/I_0 is then divided by N_t/R in order to calculate E_f/N_t.

The normalized per frame signal to noise ratio, E_f/N_0 used to calculate the normalized per frame signal can be calculated as follows. The dot product of the re-encoded symbols d and the soft decisions $d\alpha E_T/I_0$ can be computed for each rate of the fundamental block. The result can be squared and divided by the estimated pilot energy as shown:

$$E_P/I_0 = \alpha^2 E_T/I_0 \qquad \textbf{EQN. (11)}$$

The dot products for each rate of the fundamental block can be normalized using the ratio of the number of symbols in a full rate block to the number of symbols in the block. If the fundamental block rate is not known the maximum normalized dot product can be selected. The per frame noise to interference ratio, N_t/I_0 can then be measured by accumulating the energy in a forward code channel over the frame.

Signals representative of the signal to noise ratio can be used for the control of power transmission levels in the system and method of the present invention. In the preferred embodiment of the invention for example, the base

stations 12, 14, 16 can use the FWD_SNR_DELTA value sent to it by the mobile station 18. The FWD_SNR_DELTA value is sent to the base stations by the mobile station 18 on the power control subchannel of a reverse frame n to adjust the forward gain (FWD_GAIN) it applies to a forward frame n+1.

In order to calculate FWD_SNR_DELTA the mobile station 18 can use an expected signal to noise value along with the calculated signal to noise value. The per frame expected signal to noise ratio E_f/N_t can be calculated as follows. The mobile station 18 can set the initial expected value equal to the ratio of the first fundamental block that it successfully decodes. If the fundamental block is erased the mobile station 18 increases the expected value of E_f/N_t. Otherwise, the mobile station 18 decreases the expected value of E_f/N_t.

The increase step size P_i and the decrease step size P_d are determined by the desired forward link fundamental block erasure rate R_e and the maximum rate of increase of E_f/N_t. This maximum rate of increase can be defined as P_m. Then, $P_d = (R_e P_m)/(R_e-1)$ and $P_i = (P_d / R_e)$. P_m can have a value of one-half.

If the power control subchannel FWD_SNR_DELTA is not erased by the base stations 12, 14, 16, the forward per symbol signal to noise ratio delta flag (FWD_SNR_VALID) is set to 1. Otherwise, the base stations 12, 14, 16 set both the FWD_SNR_DELTA and FWD_SNR_VALID values to 0. The forward gain applied by the base station transmitter to forward transmit frame n+1 is then calculated as follows:

$$\text{FWD_GAIN}[n+1] = \begin{cases} \text{FWD_GAIN_MIN, where } \text{FWD_GAIN}_{adj} < \text{FWD_GAIN_MIN} \\ \text{FWD_GAIN_MAX, where } \text{FWD_GAIN}_{adj} > \text{FWD_GAIN_MAX} \\ \text{FWD_GAIN}_{adj}\text{, otherwise} \end{cases} \quad \textbf{EQN. (12)}$$

where $\text{FWD_GAIN}_{adj} = \text{FWD_GAIN}[N]*10^{-X}$, and superscript X is determined according to FWD_SNR_DELTA and FWD_SNR_VALID. It will be understood, however, that any method of calculating FWD_GAIN can be used in accordance with the system and method of the present invention.

Referring now to FIG. 2, there is shown a portion of power control subchannel 30. Power control subchannel 30 is suitable for use in the communication system of FIG. 1. For example, power control subchannel 30 can be used to transmit FWD_SNR_DELTA from the mobile station 18 to the

base stations 12, 14, 16 in order to control the power level of transmissions to the mobile station 18.

Power control subchannel 30 can be located within a pilot channel carrying a plurality of power control groups 34. For example, sixteen power control groups 34 can form each of a plurality of frames 38 within the pilot channel. Each power control group 34 can contain a plurality of pseudorandom noise words 38. In practicing the method of the present invention one or more pseudorandom noise words 38 can be removed and replaced with power control information 40.

The removed pseudorandom noise words 38 can be any noise words 34 within the length of power control group 34. However, in a preferred embodiment, noise words 38 located towards the center of power control group 34 are used. It is preferred that power control information 40 instruct a transmitter to increase or decrease the transmit power level a specified amount or to leave the transmit power level unchanged, as shown in Eqn. (12). Furthermore, it is also preferred that the transmission of frame 38 containing power control information 40 in this manner be repeated several times in order to increase reliability.

It will be understood that any power control information can be transmitted by puncturing the power control information into selected positions within a power control group 34. In addition, it will be understood that this method of puncturing power control information into the pilot channel may be advantageously applied to any of the methods for determining power control information set forth herein.

The foregoing description of the preferred embodiments of this invention is provided to enable a person of ordinary skill in the art to make and use the invention claimed herein. Various modifications to these embodiments will be readily apparent to those skilled in the art, and the principles described can be applied to other embodiments without the use of any inventive faculty. Therefore, the present invention is not to be limited to the specific embodiments disclosed but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

What is claimed is:

CLAIMS

1. A method for determining signal to noise ratio transmissions received within a communication system including a communication channel and a pilot channel, comprising the steps of:

(a) measuring the per symbol signal to interference ratio over a predetermined amount of time;

(b) measuring the noise to interference ratio over a second predetermined amount of time;

(c) dividing the measured per symbol signal to interference ratio by the measured noise to interference ratio; and

(d) providing the quotient to a network controller.

2. A system for controlling the power level of transmissions within a communication system having a base station, a mobile station and a plurality of channels including a communication channel and a pilot channel, comprising:

(a) a signal strength value determined by the mobile station according to a communication signal received by way of the communication channel;

(b) a pilot channel signal determined according to a pilot signal transmitted by way of the pilot channel;

(c) signal to noise ratio of the communication signal determined according to the signal strength value and the pilot channel signal; and

(d) a transmitter for controlling the power level of a transmission according to the signal to noise ratio.

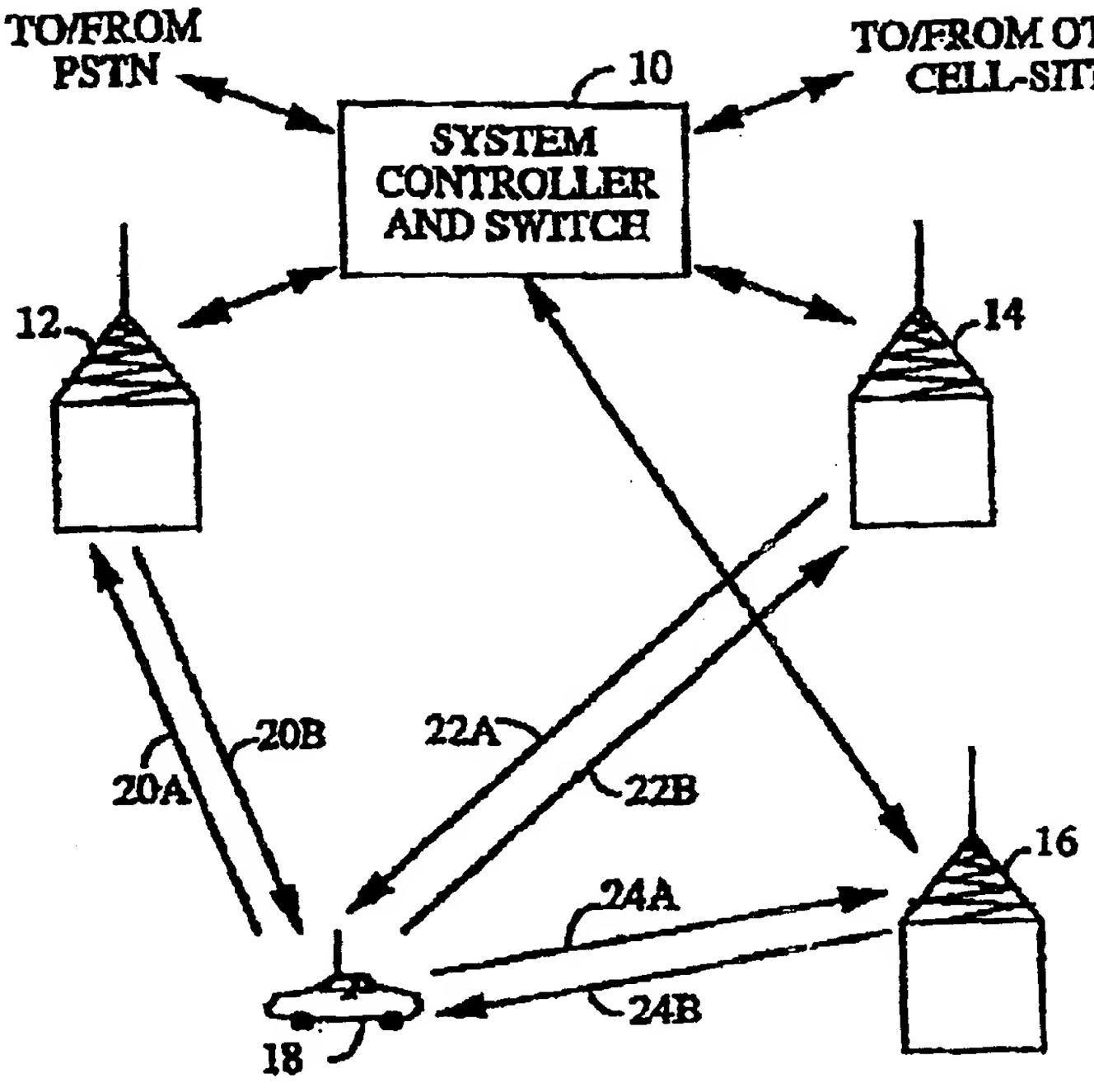
TO/FROM PSTN
10
TO/FROM OTHER CELL-SITES
SYSTEM CONTROLLER AND SWITCH
12
14
16
18
20A
20B
22A
22B
24A
24B

FIG. 1

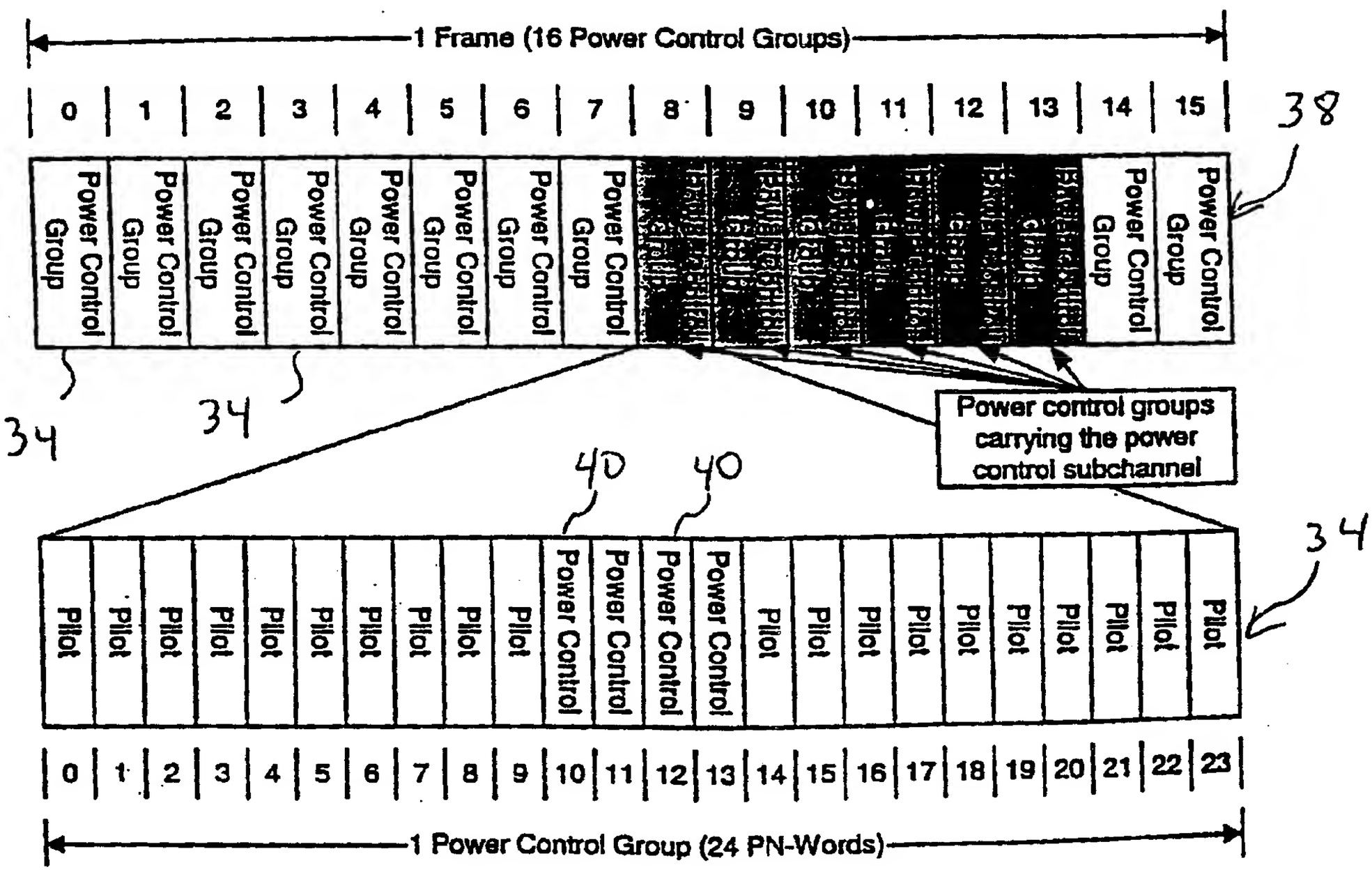
30
1 Frame (16 Power Control Groups)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
38
Power Control Group
34
Power control groups carrying the power control subchannel
40
Pilot
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
1 Power Control Group (24 PN-Words)

FIG. 2

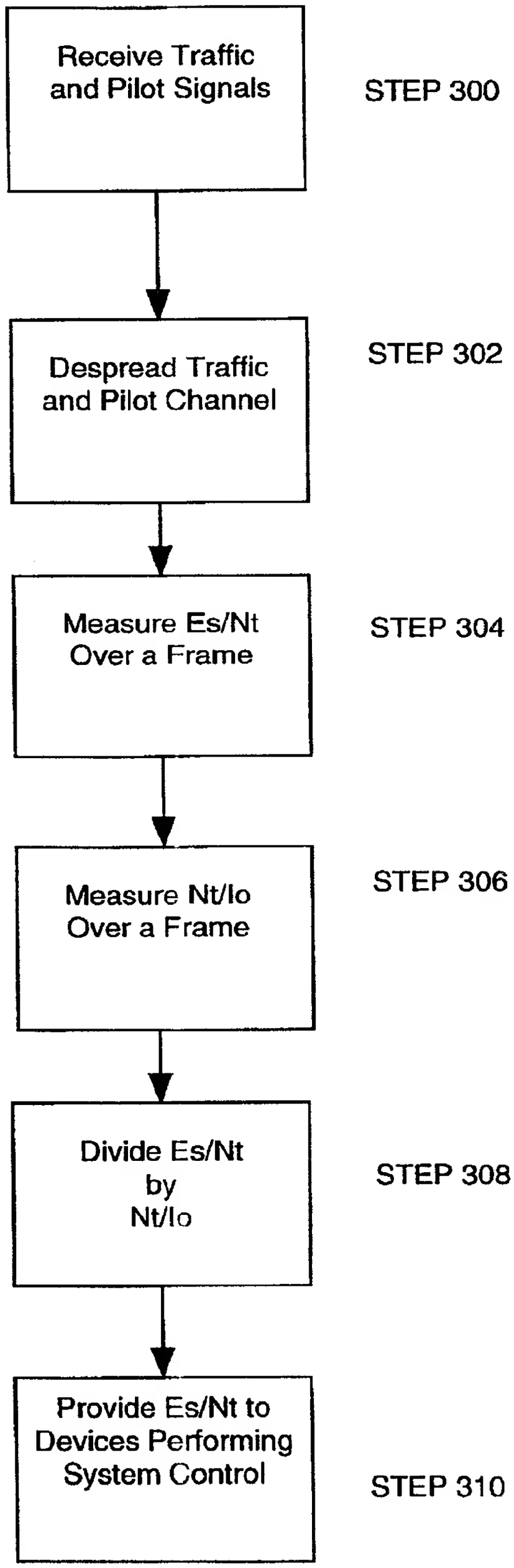
Receive Traffic and Pilot Signals
STEP 300
Despread Traffic and Pilot Channel
STEP 302
Measure Es/Nt Over a Frame
STEP 304
Measure Nt/Io Over a Frame
STEP 306
Divide Es/Nt by Nt/Io
STEP 308
Provide Es/Nt to Devices Performing System Control
STEP 310

FIGURE 3

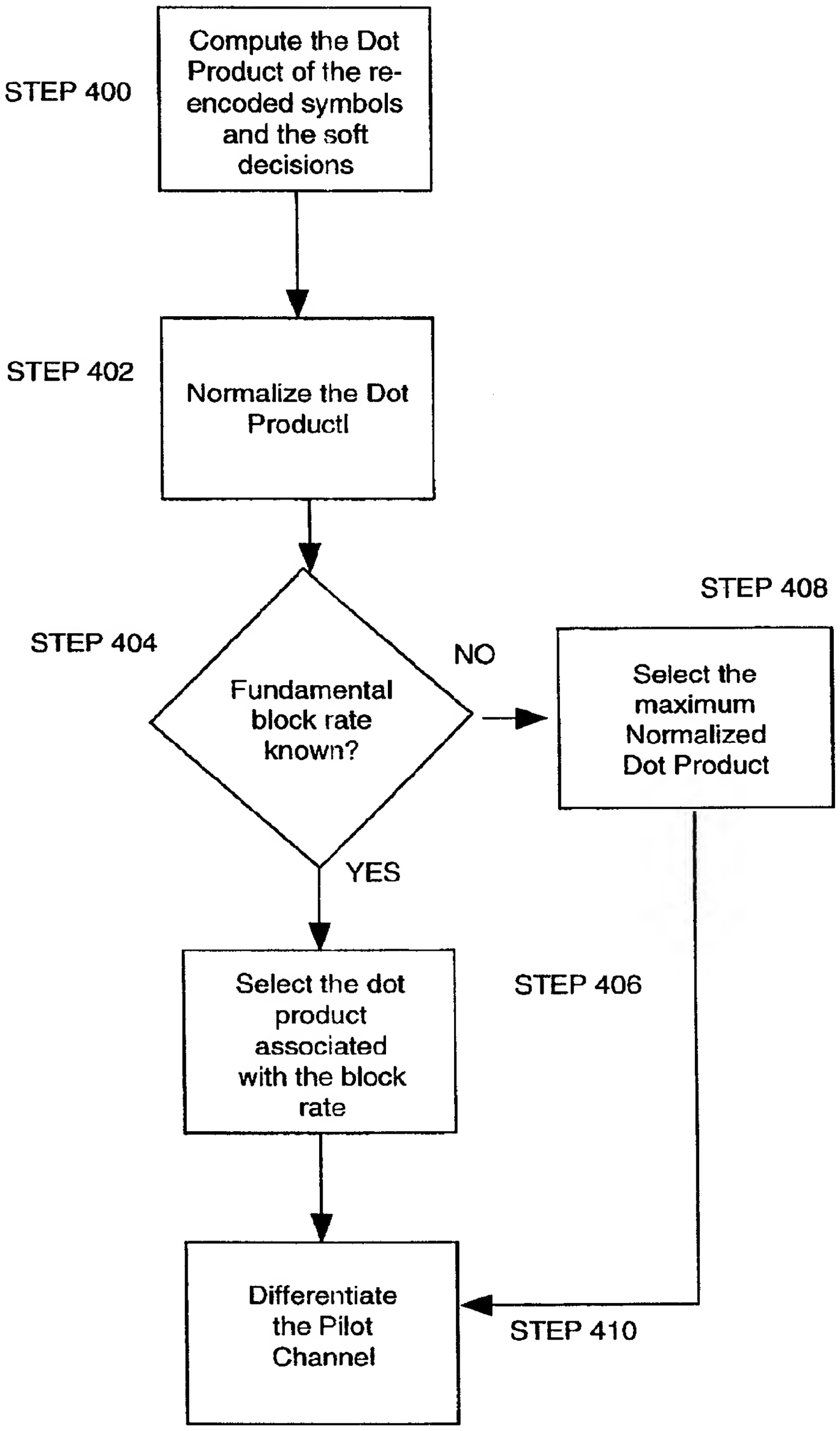
STEP 400
Compute the Dot Product of the re-encoded symbols and the soft decisions
STEP 402
Normalize the Dot Productl
STEP 404
Fundamental block rate known?
NO
STEP 408
Select the maximum Normalized Dot Product
YES
Select the dot product associated with the block rate
STEP 406
Differentiate the Pilot Channel
STEP 410

FIGURE 4

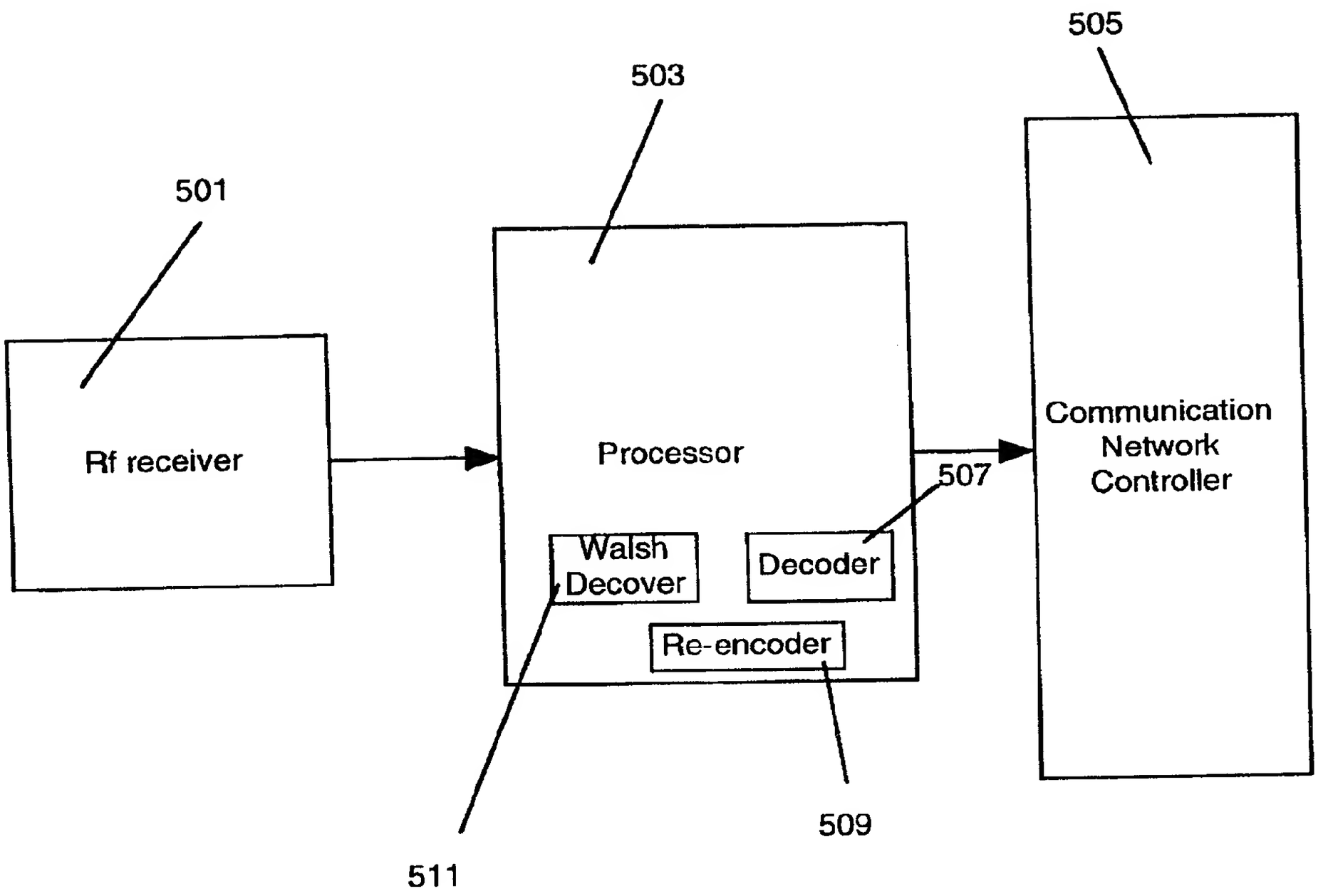
501
503
505
Rf receiver
Processor
Communication Network Controller
507
Walsh Decover
Decoder
Re-encoder
509
511

FIGURE 5

INTERNATIONAL SEARCH REPORT

Ir ational Application No
PCT/US 99/03683

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04B7/005 H04B17/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04B H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y A	WO 98 02981 A (ERICSSON) 22 January 1998 see page 8, line 10 - page 18, line 30 ---	2 1
Y	US 5 697 053 A (HANLY) 9 December 1997 see column 3, line 36 - column 6, line 58; figures ---	2
A	WO 97 34439 A (QUALCOMM) 18 September 1997 see page 20, line 7 - page 42, line 23; figures ---	1,2
A	WO 97 02665 A (ITC) 23 January 1997 see page 5, line 8 - page 23, line 3; figures ---	1,2
A	EP 0 680 160 A (NTT) 2 November 1995 see page 4, column 6, line 2 - page 6, column 9, line 20; figures --- -/--	1,2

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 June 1999	25/06/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Geoghegan, C

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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Ir ational Application No
PCT/US 99/03683

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	WO 95 12297 A (QUALCOMM) 4 May 1995 see page 10, line 1 - page 22, line 11; figures -----	1,2

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Ir ational Application No
PCT/US 99/03683

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		FI 961446 A	29-05-1996
		IL 111434 A	06-12-1998
		JP 9507115 T	15-07-1997
		SG 52653 A	28-09-1998
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